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HISTOPATHOLOGIC SURVEY OF 2,500 GERMAN  
SHEPHERD MILITARY WORKING DOGS

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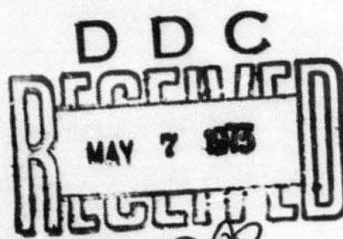
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# Histopathologic Survey of 2,500 German Shepherd Military Working Dogs

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## SUMMARY

Histopathologic examinations of specimens from 2,500 military working dogs were done. The gross necropsies were performed at U.S. military installations throughout the world. Approximately two-thirds (1,646) of the dogs were euthanatized for medical and non-medical reasons. The remaining third died of naturally occurring disease or injuries; a specific cause of death was identified in approximately half of those. The leading causes of death were ehrlichiosis, neoplasms, dirofilariasis, and physical events (such as injuries or heat); in addition, lesions without demonstrable etiologic agents were sufficiently extensive to cause clinical signs and probably contributed to the death or destruction of the dog. Of 131 surgical biopsy specimens submitted, 93 were neoplasms.

Medical problems in military working dogs have been described in several reports. Hip dysplasia was a serious problem in the selection of German Shepherd Dogs for

military duty<sup>14</sup> and was roentgenologically studied.<sup>18</sup> A wide spectrum of clinical disease entities was reported in the military working dogs (MWD) in Vietnam; acute glossitis was the single greatest cause of loss of duty time in 1970.<sup>11</sup> Tropical canine pancytopenia (ehrlichiosis), caused by *Ehrlichia canis*, was responsible for approximately 200 deaths of dogs from 1968 to 1970 before the causative agent was determined and control measures were developed and instituted.<sup>8-10</sup> Melioidosis was reported in 4 dogs and the lesions were described;<sup>17</sup> serologic screening indicated past infections in several other dogs.<sup>2</sup>

A high-caloric ration capable of being stored for long periods without deterioration was developed to provide for the nutritional needs of the MWD.<sup>13</sup> Significant occurrences of heartworm and hookworm diseases were causes for adding styrylpyridinium and diethylcarbamazine to the prepared ration to control the debilitating influences of *Dirofilaria immitis* and *Ancylostoma caninum*.<sup>5,6</sup> An unusual manifestation of dirofilariasis was occlusion of cerebral arteries along with subsequent massive necrosis.<sup>15</sup>

The purpose in the present report is to review the lesions in specimens obtained from 2,500 MWD that were accessioned at the Armed Forces Institute of Pathology (AFIP) since 1964.

## Materials and Methods

Tissues from MWD were received at the AFIP on a routine basis for several years, and the number increased in proportion to military activities in Southeast Asia. The 2,500 military working dogs in this study were those accessioned at the AFIP from mid-1954 through mid-1971 (Table 1). In addition, 131 surgical biopsy specimens were submitted and examined

TABLE 1—Number of Necropsy Cases from German Shepherd Military Working Dogs Accessioned by Year

Year accessioned	No. of cases
1964	39*
1965	131
1966	117
1967	308
1968	510
1969	662
1970	606
1971	127*
Total	2,500

\* Not a full year's accessions.

over the same period. The necropsies were performed and surgical specimens were collected by military veterinarians at U.S. military installations throughout the world.

All dogs were of the German Shepherd Dog breed (breed registration, however, was not required for acceptance for military service). Of the cases submitted, 2,281 were males, and 160 were females (Table 2). Female dogs were spayed as a prerequisite for acceptance for military service. Sex was not recorded for 59 dogs. Age ranged from 1 to 14 years; age was not recorded for 170 dogs. Male dogs had a mean age at death of 6.3 years, with the median being in the 7-year-old age group. Mean and median age of the female dogs was 6 years.

TABLE 2—Age at Necropsy and Sex of 2,500 German Shepherd Military Working Dogs

Age (yr.)	Males	Females	Sex unknown	Total
1	77	3	1	81
2	166	19	3	188
3	219	14	0	233
4	209	13	1	223
5	183	19	0	202
6	185	14	0	199
7	217	16	3	236
8	293	25	0	318
9	328	20	0	348
10	207	8	2	217
11	54	3	1	58
12	20	1	0	21
13	5	0	0	5
14	1	0	0	1
Age unknown	117	5	48	170
Total	2,281	160	59	2,500

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TABLE 3—Numbers of Necropsy Cases of German Shepherd Military Working Dogs and of Surgical Biopsy Specimens Received for Histopathologic Diagnosis

Military service	Continental United States			Overseas		
	Necropsy cases			Necropsy cases		
	Dogs that died	Dogs that were euthanatized	Surgical biopsy specimens	Dogs that died	Dogs that were euthanatized	Surgical biopsy specimens
Army	74	91	14	412	819	39
Air Force	205	443	39	163	293	39
Total	279	534	53	575	1,112	78

The number of cases submitted according to source is given (Table 3). Two principal categories of necropsy cases were (1) dogs that died naturally and (2) dogs that were euthanatized for various reasons. Euthanasia was performed for both medical and nonmedical reasons. Medical reasons usually were the diagnosis of incurable disease or impaired effectiveness, resulting from chronic or debilitating disease. Nonmedical reasons included overaggressiveness, underaggressiveness, gun-shyness, lack of stamina, and inability to be retrained with another handler.

Specimens were fixed in 10% formalin and shipped to the AFIP with accompanying necropsy protocols. Tissues from each dog were examined grossly, and appropriate specimens were processed for microscopic examination. These tissues were embedded in paraffin, and sections cut 5  $\mu$ m. thick were stained with hematoxylin and eosin. Special stains were used to demonstrate specific structures, organisms, or cellular elements. Microscopic diagnoses were entered in the AFIP computer system along with various demographic data. The data were then compiled and categorized according to origin of the case, major diagnoses, and probable cause of death.

## Results

**Dogs That Died Naturally.**—Of the 854 dogs that died, for 250 the cause of death could be related to a specific etiologic agent (Table 4). *Ehrlichia canis* was the leading cause of death, followed in order of frequency by malignant neoplasms, physical causes, *D. immitis*, toxins, and infective agents. Toxins included snakebites, chemicals, pesticides, and therapeutic agents. Physical causes were wounds, physical trauma, heatstroke, strangulation, and lightning.

Lesions of unknown cause were recorded as direct causes of death in 152 dogs (Table 5). Lesions in

the respiratory system included the various forms of bronchopneumonia of bacterial and inhalation or aspiration types. The lesions of the latter type usually were due to aspiration of vomitus or accidental aspiration of medicaments and diagnostic materials such as radiopaque substances. Lesions in the urinary tract included chronic interstitial nephritis, with uremia, hemorrhagic cystitis, and ruptured renal cystadenoma (1 case).

Lesions of unknown cause were believed to be the cause of death included hemorrhagic gastritis, gastric torsion, bloat, volvulus and intussusception, perforated ulcer,

esophagitis, and achalasia of the esophagus. Myocarditis, endocarditis, and valvular endocardiosis accounted for the marked lesions observed in the cardiovascular system. Nonspecific hepatitis, cholangiohepatitis, and fibrosis represented severe lesions in the liver. There were a few cases of pleuritis or peritonitis. Encephalitis or meningoencephalitis were recorded, as was one case of hydrocephalus. There were 2 cases in which the musculoskeletal system was involved. In one of these, herniation of intervertebral disks and spinal cord malacia were seen; the other was a case of severe myositis.

**Euthanatized Dogs.**—Many malignant neoplasms and marked lesions in various organ systems were seen in specimens from dogs that were euthanatized (Tables 4 and 5).

Diagnosis of the cause was made on 206 dogs. Advanced lesions from infection by *E. canis* were seen in 107 cases. Malignant neoplasms, some not suspected clinically or ob-

TABLE 4—Numbers of German Shepherd Military Working Dogs That Died or Were Euthanatized for Which the Cause Was Diagnosed

Cause of death	Dogs that died		Dogs that were euthanatized		Total
	United States	Overseas	United States	Overseas	
Ehrlichiosis	0	84	0	107	191
Neoplasms	20	33	23	35	111
Dirofilariasis	20	16	13	17	66
Physical	7	44	1	3	55
Toxins	3	10	0	0	18
Viral	2	1	1	1	5
Bacterial	0	2	2	0	4
Mycotic	1	1	1	1	4
Protozoan	0	1	0	0	1
Parasitic	0	0	0	1	1
Subtotals	58	192	41	165	456
Total of groups	250		206		456

TABLE 5—Numbers of German Shepherd Military Working Dogs That Died or Were Euthanatized and Had a Severe Lesion in the Organ or System Indicated but in Which a Causative Agent Was Not Identified

Organ or system	Dogs that died		Dogs that were euthanatized		Total
	United States	Overseas	United States	Overseas	
Respiratory	21	26	9	21	77
Urinary	12	19	12	32	75
Digestive	20	20	3	25	68
Musculoskeletal	1	1	17	45	64
Cardiovascular	2	8	7	11	28
Eye	0	0	16	8	24
Nervous	3	2	5	12	22
Serous surfaces	5	4	0	2	11
Liver	2	4	1	3	10
Skin	0	0	4	5	9
Spleen	1	1	2	0	4
Subtotals	67	85	76	164	392
Total of groups	152		240		392

served grossly, were diagnosed in 58 dogs. Various lesions from *D. immitis* infestations causing clinical disease leading to euthanasia were seen in 30 cases.

Lesions in organs or systems that probably caused clinical disease or marked debility were observed in 240 euthanatized dogs. Marked degenerative coxofemoral joint osteoarthropathy (hip dysplasia) was observed in 62 cases; numbers of hip joints studied microscopically were limited, however. Cases of chronic interstitial nephritis and sequelae were next most numerous, followed by cases with severe lesions in the respiratory system, digestive system, eye, and others.

**Neoplasms.**—Necropsy Specimens.—Of the neoplasms from all dogs that died naturally or were euthanatized, 224 were benign and 112 were malignant (Table 6). Neoplasms were seen in male dogs, with the exception of 1 benign and 2 malignant neoplasms in female dogs. The largest number of benign neoplasms was in the urogenital system, with seminomas being the most numerous. Hemangiosarcomas made up the largest number of malignant neoplasms. There were 14 malignant neoplasms that were so undifferentiated or widely metastasized that the primary site or cell type was not determined.

Of the endocrine tumors, adrenal cortical adenomas and thyroid adenomas were most numerous. Adenocarcinoma of the thyroid gland was the most numerous of malignant endocrine neoplasms. Melanomas were diagnosed from the gingiva, eyes, and skin. Malignant lymphomas were diagnosed in 13 cases, and 1 thymoma was seen.

A choroid plexus papilloma and an acidophil adenoma of the pituitary gland were the only intracranial neoplasms. Also, of 5 chemodectomas, 3 were located at the base of the heart and metastasized to other organs.

**Surgical Biopsy Specimens.**—A wide variety of benign cutaneous neoplasms was diagnosed. Basal cell and adnexal tumors were the most numerous. Only 10 malignant neoplasms of the skin were diagnosed.

## Discussion

The data in the present report were probably from the largest single collection of cases of any one breed of working or domestic dog. The German Shepherd Dogs comprising this group were a selected population in that they met certain standards of age, height, conformation, color, and health before they were accepted for military service.<sup>14</sup>

Hip dysplasia and coxofemoral osteoarthritis were the leading causes for medical rejection for military duty and for premature disability.<sup>14</sup> Since not enough German Shepherd Dogs with normal hips were available, dogs with grade I dysplasia have been used and they gave an estimated 5 to 7 years of service before incapacitation.<sup>14</sup>

Results of a study of pelvic roentgenographs of 766 German Shepherd Dogs indicated that the rate and degree of joint deterioration was less for dogs with normal hips than for those with dysplastic hips.<sup>18</sup> Results of limited studies of specimens used in the present survey indicated that hip dysplasia with concurrent osteoarthritis was a major disease entity in German Shepherd Dogs.

History of infection with *D. immitis* also was an important cause for rejection,<sup>14</sup> but disabling disease caused by heartworms was a serious medical problem in military working dogs for many years. A report in 1958 indicated that approximately 50% of the deaths of military working dogs and more than 80% of the lost time were due to *D. immitis* at Pacific and Far East installations.<sup>3</sup>

The presence of *D. immitis* was noted in 226 cases, and *D. immitis* infection caused lesions in 66 cases, probably contributing to death of the dog or at least causing serious clinical disease. These lesions were usually seen in the lungs, where dead parasitic emboli had caused massive infarcts. In one reported case, *D. immitis* caused vascular occlusion of cerebral arteries and subsequent massive necrosis and malacia of one cerebral hemisphere.<sup>15</sup> Nonfatal lesions in the lungs similar to those reported in other dogs<sup>1,19</sup> consisted of marked chronic villous endarteritis of branches of

the pulmonary artery and also organized thrombi with recanalization of blood vessels.

Microfilariasis has been a frequent finding in dogs with heartworms, but is decreasing in incidence. This is presumably due to the feeding of diethylcarbamazine in the ration fed to the military working dog. The efficacy of this drug and styrylpyridinium for the control of the heartworm and the hookworm *A. caninum* in military working dogs was reported in 1971,<sup>6</sup> and the inclusion of the drugs in the feed was instituted as a routine practice. Hookworm disease was reported to be the most persistent parasitism in military dogs in Vietnam,<sup>11</sup> but was diagnosed in the present specimens only as an incidental lesion. There are a multitude of other nonfatal lesions in these cases that cannot be detailed in a single report. Some of the most common of these have been reported.<sup>4</sup>

The low frequency of the common infectious diseases (canine distemper, infectious canine hepatitis, and leptospirosis) in the present series is no doubt related to the comprehensive immunization program carried out by veterinarians responsible for the clinical health of the dogs.

Ehrlichiosis, caused by the rickettsial organism *E. canis*, was responsible for more naturally occurring deaths and conduct of euthanasia than any other in the present dogs. This disease was described in 1935 in Algeria<sup>7</sup> but was not considered a major disease problem until the epizootic occurred in military working dogs in Southeast Asia in 1968. The disease was then referred to as idiopathic hemorrhagic syndrome and, later, tropical canine pancytopenia; with the identification of *E. canis* as causal agent, the disease is now designated canine ehrlichiosis.<sup>10</sup> The histopathologic changes in German Shepherd Dogs were infiltrations of large numbers of lymphocytes and plasma cells in many organs, including kidney, spleen, lung, lymph nodes, retina of the eye, and intracranial meninges.<sup>8</sup>

\* Hildebrandt, P. K., Walter Reed Army Institute of Research, Washington, D.C.: Unpublished data, May 15, 1972.

TABLE 6—Numbers of Neoplasms Diagnosed in Necropsy Specimens from 2,500 German Shepherd Military Working Dogs and in 131 Surgical Biopsy Specimens

System	Neoplasm	Benign			Neoplasm	Malignant		
		Necropsy specimen		Surgical biopsy specimens		Necropsy specimen		Surgical biopsy specimens
		Dogs that died	Dogs that were euthanatized			Dogs that died	Dogs that were euthanatized	
Musculoskeletal		0	0	0	Sarcoma, undifferentiated	1	1	0
					Osteosarcoma	1	1	3 (1)
					Chondrosarcoma	0	2	0
Digestive	Papilloma (mouth)	1	0	1	Melanoma (gingiva)	0	1	1
	Epulis (gingiva)	0	1	0	Squamous cell carcinoma (tonsil)	1	1	0
	Leiomyoma (stomach)	0	1	0	Carcinoma (stomach)	1	0	0
	Leiomyoma (duodenum)	0	1	0	Leiomyosarcoma (intestine)	1	0	0
	Polyp (colon)	0	0	1	Adenocarcinoma (colon)	0	2	0
	Polyp (rectum)	0	0	1				
	Adenoma (anus)	0	1	0	Carcinoma, acinar (pancreas)	1	1	0
	Adenoma (liver)	1	0	0	Adenocarcinoma (liver)	0	1	0
	Papilloma (gallbladder)	1	1	0	Adenocarcinoma (bile duct)	1	2	0
Respiratory	Adenoma (lung)	0	1	0	Adenocarcinoma (lung)	1	2	0
					Papillary carcinoma (lung)	1	0	0
					Fibrosarcoma (pleura)	0	1	0
Mediastinum	Neurofibroma	0	1	0	Leiomyosarcoma	0	1	0
Urogenital	Cystadenoma (kidney)	1	0	0	Carcinoma (kidney)	0	1	0
	Fibroma (bladder)	0	1	0	Transitional cell carcinoma (bladder)	2	2	0
	Papilloma (bladder)	0	1	0				
	Seminoma, intratubular (testis)	12	40	0	Sertoli cell tumor (testis)	0	2	0
	Seminoma (testis)	10	23	1	Adenocarcinoma (prostate)	0	2	0
	Interstitial cell tumor (testis)	5	27	1				
	Sertoli cell tumor (testis)	8	19	2				
Peritoneum	Mesothelioma	0	1	0				
Endocrine glands	Adenoma (thyroid gland)	1	8	0	Adenocarcinoma (thyroid gland)	3	3	0
	Adenoma (parathyroid gland)	0	3	0	Carcinoma (parathyroid gland)	0	1	0
	Adenoma, acidophil (hypophysis)	0	1	0				
					Thymoma (thymus)	1	0	0

Continued

Melioidosis (caused by *Pseudomonas pseudomallei*) was reported in 4 of 31 U.S. Army dogs in Vietnam that died of disease (medical causes). Gross lesions were inconsistent and could be confused with those caused by other pyogenic infections, making isolation and identification of the organism necessary for diagnosis.<sup>17</sup> These cases were recently submitted to the AFIP and were not included in the present 2,500 cases. Melioidosis was not diagnosed microscopically in the present survey, although significant titers were reported in 7 cases. Only 1 of these cases had lesions indicative of a pyogenic infection. In a serologic survey of 64 dogs returned

to the United States, 19% had significant titers according to the indirect hemagglutination test for melioidosis.<sup>2</sup>

Diagnosis of a case of tuberculosis made on the basis of the detection of acid-fast bacilli in lesions characteristic of tuberculosis in dogs was made in 1 dog that was stationed in Turkey.

Acute glossitis ("red tongue") was reported to be a serious disease occurring in 15.8% of the dogs in Vietnam over a given period, with a mean loss of 9.2 days per dog.<sup>11</sup> The disease is idiopathic, and recovery is usual if the dog is placed in the shade and allowed to rest. When these dogs are eventually ne-

cropsied, the lesion is manifested as a chronic glossitis with focal atrophy of the filiform papillae.<sup>b</sup>

Chronic interstitial nephritis, frequently seen in aging dogs, was a common finding in the present series.

Deaths from physical insults such as wounds from enemy action, trauma of various types, heatstroke, accidental strangulation, and lightning were probably unique to the military working dog. In 18 of the present cases, death was due to missiles (bullets) or explosive devices (booby traps and hand gre-

<sup>b</sup> Voelker, F. A., Armed Forces Institute of Pathology, Washington, D.C.: Personal communication, May 15, 1972.

TABLE 6 (Continued)—Numbers of Neoplasms Diagnosed in Necropsy Specimens from 2,500 German Shepherd Military Working Dogs and in 131 Surgical Biopsy Specimens

System	Neoplasm	Benign			Surgical biopsy specimens	Malignant			Surgical biopsy specimens
		Necropsy specimen		Necropsy specimen		Necropsy specimen	Surgical biopsy specimens		
		Dogs that died	Dogs that were euthanatized						
Endocrine glands	Adenoma, cortical (adrenal gland)	4	14 (1)	0	Pheochromocytoma (adrenal gland)	0	1	0	
	Adenoma, medullary (adrenal gland)	0	1	0					
	Adenoma, islet cell (pancreas)	2	0	0					
Vascular	Hemangioma	3	6	7	Hemangiosarcoma	22 (1)	7	1	
Hematopoietic					Lymphoma	7 (1)	6	2	
Nervous	Papilloma (choroid plexus)	0	1	0	Heart-base tumor	1	2	0	
	Heart-base tumor	1	1	0	Paraganglioma	1	0	0	
Sense organs	Melanoma (eye)	0	2	1	Melanoma (eye)	0	2	1 (1)	
Skin and adnexa	Epidermal inclusion cyst	0	4	6					
	Dermoid cyst	0	0	3 (1)					
	Sebaceous cyst	0	0	2 (1)					
	Sudoriferous cyst	0	0	1					
	Basal cell tumor	1	2	8	Adenocarcinoma (sweat gland)	0	0	2	
	Adenoma (sweat gland)	0	0	2	Adenocarcinoma (adnexa)	0	2	0	
	Adenoma (sebaceous gland)	0	1	3	Carcinoma (peri-anal gland)	0	0	1	
	Trichoepithelioma	0	0	2					
	Adenoma (adnexa)	0	0	3					
	Adenoma (perianal gland)	2	3	4					
	Mixed tumor (mammary gland)	0	0	2 (2)					
	Mast cell tumor	0	1	6 (1)					
	Hemangiopericytoma	1	0	2					
	Keratoacanthoma	0	0	6					
	Histiocytoma	0	0	3					
	Transmissible venereal tumor	0	0	3					
	Calcinosis circumscripta	0	0	3	Carcinoma, squamous cell	2	0	1	
	Fibroma	1	0	1	Fibrosarcoma	0	0	4	
	Melanoma	0	1	0	Sarcoma, undifferentiated	0	1	0	
	Lipoma	1	0	1	Melanoma	0	2	2	
Malignant (primary undetermined)		—	—	—	Carcinoma	6	7	0	
		—	—	—	Sarcoma	1	0	0	
	Subtotals	56	168	75		55	57	18	
	Totals of groups	224		75		112		18	

Numbers in parentheses indicate number of females.

nades). Heatstroke accounted for the deaths of 17 dogs.

Hemangiosarcomas were the most numerous of the malignant neoplasms in the present study. The great frequency of this neoplasm has been recorded in German Shepherd Dogs,<sup>16,c</sup> as well as in other breeds. In one series, 49 cases of hemangioendothelioma (hemangiosarcoma) in several breeds were recorded in a total of 12,635 necropsy cases over a period of 25 years; there was an overrepresentation in the Alsatian (German Shepherd Dog) and Boxer breeds.<sup>20</sup> Primary

cardiac hemangiosarcomas were reported in 31 dogs, many of which were old and of the German Shepherd Dog breed.<sup>12</sup>

The high frequency of seminomas was unexpected and probably is the result of examining a large number of tissues that ordinarily would not be collected for histopathologic examination. The number and the spectrum of skin neoplasms are representative of those routinely examined from a cross section of the general canine population in the files of the AFIP.

The lesions and neoplasms recorded from the present population serve as a basis for forecasting medical problems in the MWD as well as

in German Shepherd Dogs in the civilian population.

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